

THE ESSENTIAL OILS OF SOME WESTERN AUSTRALIAN PLANTS.

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This paper describes the essential oils of the following plants:
—*Eucalyptus spathulata*, *E. Campaspe*, *Agonis flexuosa*.

PART I.

THE ESSENTIAL OIL OF EUCALYPTUS SPATHULATA (HOOKER).

Introductory.

In April, 1922, a sample of crude eucalyptus oil, labelled "E. Uncinata," was supplied to the writer by Mr. H. V. Marr, of Plaimar, Ltd., Perth. It had been distilled at Harrismith, near Narrogin, W.A., by Mr. T. A. Stewart, in March, 1921, and was forwarded to Perth, together with specimens of plant material used. The Forestry Department, W.A., had previously identified some specimens as *E. uncinata* for Mr. Stewart, and it was understood that the leaves and terminal branchlets of the same species had been used in the distillation. The chemical composition of the oil, however, was proved by this investigation to be so different from that reported by Baker and Smith for *E. uncinata*, that a search was made for the plant material which originally accompanied the oil. This was discovered and, together with fresh specimens obtained from Mr. Stewart, was submitted to Mr. C. A. Gardner, botanist to the Forestry Department, for identification. He determined the species as *Eucalyptus spathulata*. This species has two well defined forms—a mallee and a medium sized tree. The former is fairly common on the sandplains of the districts east of the Great Southern Railway, and is rendered conspicuous by its slender stems (4-9 feet) and its small bright leaves. The latter form, known popularly as Swamp Mallet or Swamp Gimlet, occurs in the sandy swamps which exist in the lake country to the east of Narrogin, Wagin, and Katanning. It is a spreading tree of 20-35 feet with a smooth trunk and thin warm red bark. It has not the fluted

trunk of *E. salubris*. The bark of this species contains up to 26 per cent, tannin. It is therefore of some commercial value. There is no record of the essential oil of this species having been previously examined.

Crude Oil.

A steam distillation of leaves and branchlets by Mr. H. V. Marr showed that the yield of crude oil was 1.43 per cent. The oil was a light orange green colour and possessed a very pleasant camphoraceous odour.

Its physical characters were as follows—

Specific Gravity at 15°C	...	...	0.9239
Optical Rotation	...	...	+ 1°.18
Refractive Index at 20°C	...	...	1.4700
Saponification Number	...	...	5.45
Saponification Number after acetylation	...	...	45.16

The oil was soluble in 4 volumes of 70 per cent. alcohol.

The saponification number corresponds to 1.93 per cent. of esters calculated as geranylacetate, $C_{12}H_{20}O_2$, while the acetyl number corresponds to 10.89 per cent. of alcohol calculated for geraniol ($C_{10}H_{18}O$). 65 per cent. of the oil was found to be cineol, determined by the B.P. method with syrupy phosphoric acid.

50 c.c. of the oil was fractionated under atmospheric pressure. Below 160deg. a little water and oil came over amounting to 2.5 per cent. This was acid in reaction and reduced Schiff's reagent. The remainder of the oil distilled as follows:—

First Fraction 160° — 165°C	...	...	20.4 per cent.
Second Fraction 165° — 172°C	...	...	17.4 „
Third Fraction 172° — 192°C	...	...	50.3 „
Fourth Fraction 192° — 240°C	...	...	6.2 „
Residue calculated by difference	...	...	3.2 „

The fractions had the following physical constants:—

—			Specific Gravity at 15°C.	Optical Rotation.	Refractive Index at 20°C.
First Fraction	...	...	0.9029	+ 7°.96	1.4623
Second Fraction	...	...	0.9123	+ 5°.69	1.4628
Third Fraction	...	...	0.9249	— 1°.84	1.4667
Fourth Fraction	...	...	0.9521	— 4°.61	1.4950

The first fraction was refractionated and 7 c.c. obtained distilling between 157deg. and 160deg. C. It still possessed a faint odour of cineol and was again refractionated, 4 c.c. being obtained distilling between 156deg.-160deg. C. It was dried with calcium chloride, placed in a freezing mixture and cooled hydrogen chloride passed into it when a solid hydrochloride was obtained melting at 126deg.-127deg. C., showing that the terpene is *d* — *a* — pinene. No crystalline nitrosite could be obtained from the third fraction, so phellandrene and terpinene are absent. The fourth fraction gave the colour reactions for the sesquiterpene aromadendrene. Bromine added to the solution in glacial acetic acid, formed a crimson colour gradually darkening to violet and then indigo. A drop of concentrated hydrochloric acid gave a similar change. Concentrated sulphuric acid in small quantities produced a bright crimson colour at the junction of the liquids. This changed to a peculiar reddish brown on mixing. Phosphoric acid gave a madder colouration at the junction of the liquids. The presence of the crystallisable phenol, australol, was indicated by the yellow colouration produced by a neutral alcoholic solution of ferric chloride, and the yellow colour of the rectified oil.^(a) The negative rotation and reducing properties of the fourth fraction indicated the presence of an aldehyde. This was estimated by shaking the crude oil for six hours with 35 per cent. sodium bisulphite. The absorption corresponded to 2.5 per cent. Baker and Smith use the term aromadendral for the mixed aldehydes usually present in eucalyptus oils, viz., aromadendral, cryptal and cuminal.^(b) Penfold has since shown^(c) that aldehyde aromadendral is really a mixture of phellandral and cuminal, but it is convenient to retain the term for the mixed aldehydes.

The residue which separated on distillation was brown in colour and had a waxlike appearance. Absolute alcohol dissolved the sesquiterpene and other bodies, leaving a white powder which was recovered by filtration. This was insoluble in ether, xylene and petroleum spirit. It was soluble in chloroform and was precipitated on the addition of alcohol. Its melting point was very high—290°-292° C. An ultimate analysis showed that it was composed of—

Carbon	..	..	..	77.5 per cent.
Hydrogen	..	..	..	9.65 per cent.
Oxygen	..	..	..	12.85 per cent.

corresponding to $C_8H_{12}O$. This compound is apparently identical with the deposit which forms in certain eucalyptus oils on standing for three or four years, and shown by Baker and Smith to be a

(a.) Baker and Smith, Research on the Eucalypts (1920), 395-396.

(b.) Idem, 61, 98, 134, 383.

(c.) Penfold, J. Chem. Soc., 1922, 121, 266.

polymerised body of exceedingly high molecular weight, probably belonging to the neutral resins.^(a)

A fresh sample of the crude oil was distilled and all the oil distilling below 190° collected. This had a very faint yellow tinge. Its specific gravity at 15° C. was 0.9191 and its optical rotation 2°.0. It was soluble in five volumes of 70 per cent. alcohol. It contained 72 per cent. cineol determined by the B.P. method. Phellandrene was absent. The rectified oil thus satisfies the requirements of the British Pharmacopœia for a medicinal eucalyptus oil.

Summary.

1. An oil supposed to be distilled from *E. uncinata* was found to have been distilled from a different species, viz., *E. spathulata*, the oil from which had not been previously examined.

2. The principal constituents have been found to be cineol, *d* — *a* — pinene, alcoholic bodies, esters, aromadendrene, aromadendral, and a polymeric body with the composition given by the formula $C_8H_{12}O$. Phellandrene and terpinene are absent.

3. The cineol content is such that when rectified the oil could be used for medicinal purposes.

PART II.

THE ESSENTIAL OIL OF EUCALYPTUS CAMPASPE (Spencer Moore).

Introduction.

Eucalyptus campaspe occurs on the Eastern Goldfields around Coolgardie, southwards to Norseman, and eastwards along the Great Western Railway for a considerable distance. It is usually a tree of 25-35 feet with a slender trunk, a smooth rich brown thin bark, brown, hard, dense timber and glaucous foliage. Although resembling the true Gimlet (*E. salubris*) in habit, it is readily distinguished by its white powdery branchlets. It occurs in fairly close formation, on red stony soil, and is plentiful in its somewhat restricted habitat. Leaves and terminal branchlets were collected by Mr. C. A. Gardner, Botanist to the Forestry Department, W.A., at Widgemooltha, near Kalgoorlie, on the 1st October, 1922. The material was forwarded to Perth, and through the kindness of Mr. H. V. Marr was distilled at the works of Plaimar, Ltd.

Crude Oil.

The yield of oil was 0.72 per cent. It was yellowish-green in colour and possessed the odour characteristic of the aldehydes of eucalyptus oils together with a secondary odour of cineol. The

(a.) Baker and Smith, Research on the Eucalypts (1920), 422.

constituents found to be present were: pinene, cymene, cineol, aromadendral, esters and alcoholic bodies. The crude oil had the following characters:—

Specific gravity at 15° C.	0.9118
Optical Rotation	5°.43
Refractive Index at 20° C.	1.4762

The oil was soluble in 5 volumes of 80 per cent. alcohol. The saponification number for esters and free acid was 8.43. After acetylation, the ester number was 72.13, indicating the presence of a considerable proportion of alcoholic bodies—18.65 per cent. calculated for a $C_{10}H_{18}O$ molecule. The cineol content is very low. It was estimated by the B.P. method with phosphoric acid and found to be about 15 per cent. Phellandrene and terpinene are absent.

Fractional Distillation.

On fractionating the crude oil 1.4 per cent. of volatile aldehydes and acid water came over below 158° C. The remainder distilled as follows:—

1st Fraction—158°-170° C. ..	31.8 per cent.
2nd Fraction—170°-190° C. ..	38.1 per cent.
3rd Fraction—190°-265° C. ..	28.7 per cent.

These fractions were examined with the following results:—

—	Specific Gravity at 15°.	Optical Rotation.	Refractive Index at 20°.
First Fraction ... ..	.8844	+ 10°.39	1.4679
Second Fraction ... ..	.8977	+ 0°.98	1.4701
Third Fraction ... ..	.9405	— 8°.45	1.4958

The terpene present is evidently *d* - *a* - pinene. This is suggested by the physical properties of the fraction distilling between 158°-170° C. The nitrosochloride was prepared in the manner proposed by Wallach and a fine-grained crystalline precipitate in small quantity obtained. This was separated and dried and found to melt at 101° C. There was not sufficient to recrystallise. The high refractive index of the second fraction indicated the presence of some other constituent and in the absence of terpenes yielding a crystalline nitrosite, cymene was suspected and found to be present in considerable quantity. The second fraction was treated with phosphoric acid and 50 per cent. resorcinol to remove cineol and alcoholic bodies, and

4 c.c. were oxidised by potassium permanganate in the usual way. The hydrated manganese dioxide was filtered and the filtrate evaporated almost to dryness. The sodium salt was successively extracted with alcohol and the solution evaporated to small bulk and water added. The solution was acidified with sulphuric acid and the separated acid crystallised from alcohol. It had a melting point of 155° C. This, together with its method of preparation, indicated *p* oxyisopropyl-benzoic acid, the oxidation product of cymene. The presence of the mixed aromatic aldehydes characteristic of eucalyptus oils, and termed "aromadendral" by Baker and Smith, is indicated by the yellowish-green colour of the second fraction and the reducing properties of the third fraction.

5 c.c. of the crude oil were shaken for 6 hours with a solution of 35 per cent. sodium bisulphite in a flask with graduated neck and the volume of the unabsorbed oil measured. Eight per cent. of the oil was absorbed.

The sesquiterpene present in the third fraction is evidently aromadendrene, as all the characteristic colour reactions of that compound are given.

Summary.

1. The constituents present are: cineol, pinene, cymene, aromadendrene, aromadendral, also esters and alcoholic bodies.
2. No economic use for this oil can be suggested at present.

PART III.

THE ESSENTIAL OIL OF *AGONIS FLEXUOSA*.

Introductory.

Agonis flexuosa is a tree very well known in Western Australia under the name of "Peppermint." A better name, but one not so generally used is the "Willow Myrtle," a name which well describes the graceful pendant branches which give to it its value as an ornamental tree. It is to be found all along the coast of the South-West from North of the Swan River to Augusta and inland along the banks of rivers and streams. In the tuart (*E. gomphoccephala*) forest it is present as an undergrowth and has to be cut back annually. It then produces a coppice growth and for this reason the Conservator of Forests, Mr. S. L. Kessell, suggested that its essential oil should be examined with a view to determining its economic value. There was no record in the Forestry Department of a systematic examination of the oil. Von Mueller in his "Extra-tropical plants of Australia" pointed out that it yielded a "yellow

oil with antiseptic properties." Parry^(a) had, in 1914, published the results of his investigation of the oil obtained by the distillation of leaves from trees growing in the Botanical Gardens, Melbourne. He showed that the oil contained the following constituents:—Pinene, cymene, cineol, esters, alcohols and a phenol. He stated that aldehydes and aromadendrene were absent and that the cineol content varied from 72 per cent. in the oil from leaves collected in autumn to 62 per cent. from those collected in winter. The results obtained by the writer show that in addition to pinene, cineol, esters, alcoholic bodies and an unidentified phenol, the aldehyde, phellandral and the sesquiterpene, aromadendrene are also present, while evidence of the presence of cynene was not obtained.

Distillation.

Preliminary steam distillations were carried on through June, 1922, in a small still at the Perth Technical School Laboratory, and these showed that the yield of oil varied with the nature of the leaves employed. Mature leaves gave a return of oil of 0.62 per cent., while that from young sucker leaves was 0.84 per cent. It was also found that prolonging the distillation gave a peculiar faecal like odour to the oil. This was traced to be due to a phenolic body. In July, 30 kilogrammes of leaves and terminal branchlets were steam distilled for me at the works of Plaimar, Ltd., and 275 c.c. of oil obtained for examination.

Crude Oil.

The crude oil was yellowish-green in colour and has the camphoraceous odour characteristic of the cineol bearing Eucalyptus oils together with a secondary unpleasant odour due to the phenolic compound present. The oil had the following physical characters:—

Specific Gravity at 15°C ...	...	...	0.9090
Optical Rotation ...	...	...	+ 5°.4
Refractive Index at 20°C ...	...	...	1.4650
Saponification Number ...	...	...	4.49
Acetylation Number ...	...	...	26.12
Solubility in 70 per cent. alcohol	...	...	Dissolved in 4 volumes.

Fractional Distillation.

The crude oil was rectified under atmospheric pressure. Below 160deg. a little acid water and oil distilled. This had reducing

(a.) R. E. Parry, Proc. Royal Soc., Victoria, XXVI (1914). p. 367.

NOTE.—E. J. Parry, "Chemistry of Essential Oils" (1921), p. 390, in giving a summary of these results attributes the work to R. H. Crozier of Melbourne, and gives as his authority Crozier "Perfumery and Essential Oil Record," IX. (1918), 58.

This reference is an extract from a report by R. H. Crozier, of Melbourne, and published in the South African Journal of Industries, December, 1917, and is a compilation of the results of various investigations into oils of the Eucalypts. R. E. Parry's work is there acknowledged.

properties suggesting volatile aldehydes. There was too little for further examination. The temperatures at which fractions were collected, their volumes and physical properties, are set out in the following table:—

Fraction.	Temperature.	Volume of fraction.	Specific Gravity at 15°C.	Optical Rotation.	Refractive Index at 20°C.
1	Below 160°C	0·8 c.	...	...	...
2	160° — 170°C	20·0 c.c.	0·9010	+ 7°·12	1·4625
3	170° — 186°C	69·2 c.c.	0·9095	+ 2°·46	1·4635
4	186° — 260°C	10·0 c.c.	0·9294	+ 1°·8	1·4813

Terpenes.

Pinene was shown to be present in the second fraction by treating 10 c.c. with 50 per cent. resorcinol and syrupy phosphoric acid to remove cineol and other oxygenated bodies. The oil unacted on was recovered and filtered from cineol phosphate crystals and the nitrosochloride of pinene obtained in the usual way by means of amyl nitrite, glacial acetic acid and hydrochloric acid. Crystallisation was assisted by the addition of alcohol. A copious precipitate was obtained. The crystals were separated, washed with alcohol and dried at 50° C. They were found to melt at 102°-103° C. There was no evidence of the presence of other terpenes. No crystalline nitrosite could be obtained from the second fraction indicating the absence of phellandrene and terpinene.

Cineol.

The presence of cineol is indicated by the strong camphoraceous odour of the crushed leaves together with that from the oil. It was estimated by the British Pharmacopoeia method with syrupy phosphoric acid; 50 c.c. of the crude oil was shaken with an aqueous solution of normal sodium hydroxide; the oil was separated, washed, dried and then rectified to 185° C. The oil which distilled below this temperature was used for the estimation. This rectified oil was colourless and possessed an extremely pleasant odour and had the following physical characters:—

Specific Gravity at 15° C.	..	..	0.9086
Optical Activity	..	..	6.78°
Refractive Index at 20°	..	..	1.4639

This rectified oil was found to contain 67 per cent. cineol, corresponding to 60.3 per cent. in the crude oil. Parry reported for the

March oil, 72 per cent. cineol for the whole oil, and 70 per cent. cineol in fractions. He estimated the cineol by means of the resorcinol method. As resorcinol absorbs not only cineol, but also alcohols, aldehydes and certain other oxygenated bodies (*a*) the result obtained by this method will be too high by an amount equal to the percentage of such substances present in the oil and absorbed. That this is so is shown very clearly by his estimates of cineol in the various fractions obtained by distillation of the crude oil. These results are set out and discussed later.

Aldehyde.

The final fraction gave evidence of reducing properties in reducing Schiff's reagent. On agitating 5 c.c. with sodium bisulphate solution for six hours, there was no crystalline precipitate. The oil was separated and the aqueous solution rendered alkaline and submitted to steam distillation, and 1.262 grams of regenerated oil recovered. This had a pleasant lemon odour, acted strongly on Schiff's reagent and, on treatment with phenyl hydrazine, yielded a hydrazone which, on separating, melted at 121-122° C. There was not sufficient oil to prepare other derivatives, but there can be no doubt that it is phellandral which, according to Penfold, yields a hydrazone melting at 122-123 C., and also forms a soluble sulphonic acid in the presence of sodium bisulphite. There was no evidence of the presence of the aldehydes cryptal, and cuminal usually associated with phellandral in Eucalyptus oils. An estimate of total aldehydes in the crude oil by absorption in sodium bisulphite corresponded to 2.5 per cent.

Phenol.

The phenolic compound was not identified. Its presence is indicated by an unpleasant secondary odour which is lost after treatment with sodium hydroxide solution. The oil used for estimation of the cineol was first shaken with a normal solution of sodium hydroxide and separated. The aqueous solution was rendered acid and extracted with ether. The ether was removed from the extract by evaporation, leaving a yellowish brown oil with a peculiar odour somewhat suggesting creosote. The alcoholic solution of the oil gave with neutral ferric chloride, a dark red colouration. Efforts to obtain crystalline benzoyl and acetyl derivatives were unsuccessful. Owing to the small amount of material available, further tests were impossible.

The Sesquiterpene.

The sesquiterpene aromadendrene was found to be present. The characteristic colour reactions were obtained by dissolving a few

(*a.*) Baker and Smith, Research on Eucalypts, p. 361.

drops of the fourth fraction in glacial acetic acid. To a portion of this solution bromine was added and a crimson colour gradually changing to indigo was obtained. Concentrated hydrochloric acid added to another portion of the solution developed a pink colour, which darkened to crimson and then changed to indigo. Phosphoric acid was added to the acetic acid solution and a madder colour was obtained at the junction of the liquids. This changed to crimson and became violet on standing. The presence of this constituent is indicative of the close relationship between this genus and that of *Eucalyptus*.

Esters.

The saponification number was 4.49, indicating the presence of 1.57 per cent. esters having the composition $C_{12}H_{20}O_2$.

Alcohols.

After acetylation the saponification number was found to be 26.12, corresponding to 6.08 per cent. alcohols calculated for an alcohol of the formula $C_{10}H_{18}O$.

Baker and Smith have shown^(a) that geranyl acetate can be estimated by saponifying the oil with alcoholic potash for two hours at the temperature of the laboratory, as under these conditions the geranyl acetate present can be completely saponified and the geraniol present in the original oil can in this way be determined. The saponification number of the acetylated oil determined in this way was found to be 11.6, corresponding to 1.98 per cent. geraniol. This shows that at least one other alcohol must be present, and in view of the low optical activity of the third fraction it was thought that there must be an optically active alcohol of dextro rotation present to compensate for the lævo rotatory effect of phellandral which is -130.6° and terpineol was suspected. A test for the presence of this alcohol was made by taking $2\frac{1}{2}$ c.c. of the oil unacted on by sodium bisulphite. This was dissolved in $2\frac{1}{2}$ c.c. of glacial acetic acid and 2 c.c. of amyl nitrite added. The mixture was cooled in ice and 2 c.c. of hydrochloric acid mixed with 2 c.c. of glacial acetic acid were added drop by drop with continual shaking. When the reaction was completed the nitroso-chloride was precipitated by means of water, separated and recrystallised from methyl alcohol. It had a melting point of $112^\circ\text{--}113^\circ\text{C.}$, thereby confirming the presence of terpineol.

(a.) Baker and Smith, "Research on the Eucalypts," p. 368.

Comparison of Results with those of Parry.

The physical characters of the crude oil and the various fractions obtained by Parry and the writer are of the same order as is shown by the following table:—

*Physical Characters of oils distilled from leaves of
Agonis flexuosa.*

Date of collection of plant material	July, 1922 ...	July, 1913 ...	March, 1913
Worker ... ..	... Phillips ...	Parry ...	Parry
Specific Gravity at 15°C	... 0.9090 ...	0.908 ...	0.900
Optical Rotation ... ..	... + 5.4° ...	+ 4.6° ...	+ 5.3°
Refraction Index at 20°	... 1.4650 ...	1.4701 ...	1.4657
Saponification Number ...	... 4.49 ...	... ..	7.5
Saponification Number after acetylation ... ..	... 26.12 ...	... ..	29.1
Solubility in 70 % Alcohol	... Dissolved in 4 volumes	... ..	Dissolved in 4 volumes
Cineol per cent. ... ..	... 60 ...	62 ...	72

The main differences are in the saponification numbers before and after acetylation which might be due to seasonal variation of esters and alcohols. The agreement in the cineol content is more apparent than real, for, as already stated, Parry estimated cineol not only in the crude oil but also in the various fractions by means of resorcinol. His results for the March oil are given in the following table:—

Cineol content of fractions obtained by absorption with resorcin^(a).

Fraction.	Temperature.	Volume of Fraction.	Cineol Content of Fraction.
I.	below 170°	5.5 c.c.	2.7 c.c.
II.	170° — 174°	12.0 c.c.	7.7 c.c.
III.	174° — 178°	13.0 c.c.	9.1 c.c.
IV.	178° — 187°	12.0 c.c.	8.6 c.c.
V.	187° — 227°	5.5 c.c.	6.1 c.c. (4.1)
VI.	above 227°	2.0 c.c.	0.8 c.c.
	Whole oil	50.0 c.c.	35.0 c.c.

(a.) Parry, Proc. Royal Soc., Victoria, Vol. XXVI., Pt. 11, p. 370.

There is an obvious error in fraction V, and Parry has informed me verbally that the cineol content should have been given as 4.1 c.c. instead of 6.1 c.c. and the total cineol as 33.0 c.c. As cineol has a boiling point of 176° C., provided the distillation has been carried out carefully, the cineol content of the fractions distilling above

187° C. should be very low, and the reported cineol in fraction V. and VI. is really due to absorption by the resorcinol of alcoholic and other oxygenated bodies. Parry reports 72 per cent. cineol for the whole oil; and 70 per cent. cineol estimated in fractions. Correcting for the error in fraction V., and deducting the absorption above 187° it is obvious that the latter figure should have been given as 56.2 per cent. The estimate of 72 per cent. for the whole oil will also be too high by the oxygenated bodies present, and making the same deduction we get 62.2 per cent. cineol for the March oil determined by resorcinol, which figure agrees fairly well with that obtained by the writer for the July oil. His result of 62 per cent. for the winter oil is subject to a similar criticism, but as the esters and alcohols for this oil were not estimated, no correction can be made. The variation in cineol content, if it does exist as stated by Parry, does not range from 62-72 per cent., but is somewhere in the vicinity of 60 per cent.

Cymene.

The presence of cymene is generally indicated by the high refractive index and low specific gravity of the appropriate fraction in which it is concentrated. In this case the refractive index of the third fraction is comparatively low—1.4635. Parry obtained for the corresponding fraction refractive indices which, when corrected for temperature, were slightly higher, viz., 1.4637 and 1.4645 for the fractions distilling between 174°-178° and 178°-187° C. He removed the cineol from the lower fraction by resorcinol and from the remaining oil obtained p. oxyisopropylbenzoic acid by oxidation with permanganate. The writer was not able to obtain this acid from the corresponding fraction after removal of cineol.

Aldehyde.

Parry reported the absence of an aldehyde. He based this conclusion on the fact that no crystalline compound was formed on shaking the crude oil with sodium bisulphite. As has been shown, the aldehyde phellandral is actually present, and as this forms a soluble suphonic acid with sodium bisulphite solution, his observation is explained.

Probable Uses of the Oil.

(1) *Medicinal*.—Owing to the high percentage of cineol present this oil should have all the therapeutic properties of the medicinal eucalyptus oils and could be used as a substitute for ordinary eucalyptus oil for medicinal purposes. Owing to the unpleasant odour of the phenol, traces of which can be detected in the main cineol fraction, it would be necessary first to remove this constituent before rectification. This would increase the cost of preparation of

the rectified oil, making it doubtful whether it could successfully compete with eucalyptus oils, which are produced very cheaply.

(2) This oil has properties of considerable importance as a flotation oil. Experiments by M. P. Bonnerup, Patent Attorney, and myself with a K and K flotation machine made by the Braun Company at the works of Copper Separation Ltd. have shown it to be remarkably efficient in separating cement copper from the gangue. Experiments in this connection are at present in progress.

Conclusions.

Summary.

1. The essential oil of *Agonis flexuosa* has been shown to contain, in addition to pinene, cineol, esters alcohols and a phenol, the aldehyde phellandral and the sesquiterpene aromadendrene, while the reported presence of cymene was not confirmed. The reported variation in the percentage of cineol present is too great.

2. The cineol content is 60 per cent., and the rectified oil could be used for medicinal purposes.

3. The crude oil can be used for flotation of cement copper.

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